22 July 1953

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MEMORANDUM FOR THE RECORD

SUBJECT: Thermocouples as a transducer head

I. Principle: A thermoelectromotive force is generated in a circuit of two dissimilar homogeneous metals if there is a temperature difference between the two junctions. The algebraic sum of this emf generated in any circuit containing any number of dissimilar homogeneous metals is a function only of the temperature of the junctions. Note that the emf is a function of relative and not absolute temperatures.

II Properties of thermocouples: Discussion will be with reference to an operating temperature range from -50 to 150°C.

The following should be considered for each application:

a) magnitude of emf/°C and characteristics

b) resistance to corrosion and general ruggedness

c) reproducibility

Not all emf vs. temperature curves are near linear. Considering our applications this is not important. Emf decay with length of TC use, however, is of consequence. This is caused mainly by corrosion, resulting in poor connections, or in a change of chemical composition of the TC wire. The lack of wire homogeneity results in spurious emf's in the circuit. These difficulties are mainly overcome by protection, either insulation or metal covering to prevent mechanical damage. Thermocouples can be made extremely rugged with a corresponding loss in sensitivity, or extremely delicate with great sensitivity. Sensitivity can be increased by TCs in series (thermopile). Note that the emf is a property of the types of metals used, but not of the wire size. In general all types of thermocouples available on the market are standardized and of long life if properly used.

Industrially, copper-constantan TC is most commonly used in the given temperature range. The copper is susceptable to corrosion; but regardless of this the couple has long life and good stablity. At 100°C (cold junction at 0°C) it generates 4.27mv. A chromel-constantan couple has a higher emf at 100°C (6.32 mv). This is available on the market but is not widely used because it is not as linear or as cheap as the copper-constantan, even though its reproducibility is as good. In addition, chromel-alumel and iron constantan couples are commonly used. With regard to reproducibility, long life, and mv output the chromel-constantan TC is the most suitable of those readily obtainable on the market. Note that linearity is of minor imporatance, but rather the couple's ability to reproduce the same emf under similar conditions is desired.

General Electric and Leeds and Northrup have many miscellaneous types of thermocouples which they use for special research problems. As any two dissimilar metals can be used, those chosen were primarily to avoid contamination, to enable great sensitivity with a fine wire size, etc., primarily operational difficulties. For our purpose a large mv output probably would be desired. With reference to Platinum, most of the intermetallic compounds of tin generate high emf (20 or 30 mv at 100°C) . Perhaps the couple with the highest emf would be a silicon-60Sb 40Cd couple., which at 100°C difference gives 85 mv. The International Critical Tables give emf characteristics for almost all compounds if specific applications arise.

has one ever been made?

III Discussion: Possible applications.

Because the TC measures only relative temperatures, possible applications are limited as a cold junction can not be maintained. boiling H_2O?

1) Radiation: a small couple can be constructed under black body conditions to detect thermal radiation. Sensitivity can range all the way from detecting a lighted candle a mile away in the darkness to that above which we can not physically tolerate. Maximum size would be about 2" cube.

2) High velocity couples: air currents carry heat away from the TC tip. These couples can be made extremely small and be very sensitive. A velocity measuring thermocouple probably would have widest applications. EMF would be roughly proportional to velocity.

usually fed back electrical to form small indicating device

3) vapor pressure:
4) rate of evaporation: this is essentially a cooling effect upon evaporation.

5) sensitive and non-sensitive couple together: all the above applications have depended upon one junction being sensitive to a change and the other not physically in a position to be so sensitive; here one would buck the emf of a coarse couple against that of the fine wire of a sensitive couple of exactly the same type.

IV Comments: Note that all applications result from physical disturbances which affect heat transfer in metals, thus causing an actual or apparent temperature differential.

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